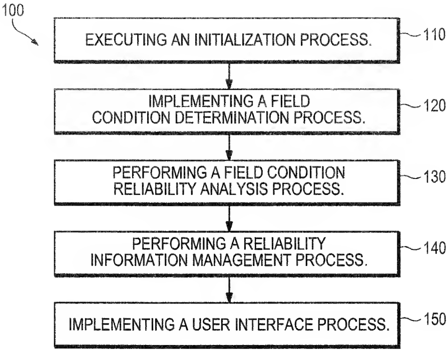
100
EXECUTING AN INITIALIZATION PROCESS.
110
IMPLEMENTING A FIELD CONDITION DETERMINATION PROCESS.
120
PERFORMING A FIELD CONDITION RELIABILITY ANALYSIS PROCESS.
130
PERFORMING A RELIABILITY INFORMATION MANAGEMENT PROCESS.
140
IMPLEMENTING A USER INTERFACE PROCESS.
150

FIG.1

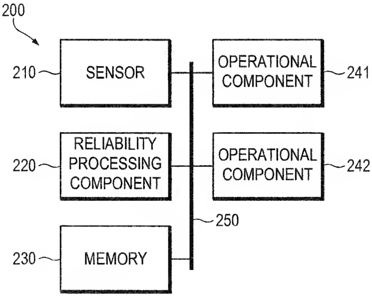
200
210
SENSOR
220
RELIABILITY PROCESSING COMPONENT
230
MEMORY
OPERATIONAL COMPONENT
241
OPERATIONAL COMPONENT
242
250

FIG.2

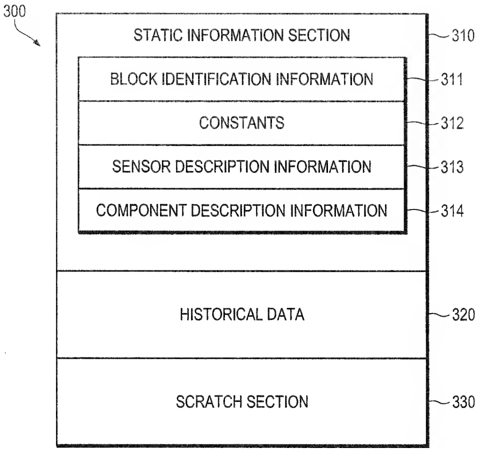
300
STATIC INFORMATION SECTION
310
BLOCK IDENTIFICATION INFORMATION
311
CONSTANTS
312
SENSOR DESCRIPTION INFORMATION
313
COMPONENT DESCRIPTION INFORMATION
314
HISTORICAL DATA
320
SCRATCH SECTION
330

FIG.3

400

Historical temperature data - Flash structure Block 0 - Static data		
Block identification This is the signature to validate the block 0 data. Checking this format FW will know data are present. The version number is necessary for every future variation of the structure. The base address is : 1FC0 0000 + 2Mbytes = 1FE0 0000		
string_id	24	$$** __xRELIABILITY__**$$
version	1	Structure version number - 1
format_time	4	Time of Format - minutes since 1/1/70 00:00:00
blk_chksum	2	Block checksum
reserved	33	Reserved for future use
Time constants These are the constant values for sampling and saving data. If the save time is greater than 1 what is saved is the average temperature read in the interval. The offset of this block is fixed at 64 bytes from the base address of the flash block.		
blk_id	2	=0x4254 "BT"
blk_chksum	2	Block checksum
bkg_t	1	Time for sampling background task - δ- in minutes
averagesample_t	1	Max time for temperature sample - Δtmaxav - multiples of δ
flashsave_t	1	Max time to save data to Flash - Δtmaxf - multiples of δ
flashclearsave_t	2	Max number of consecutive compress. rec. - Δnmaxcl
reserved	55	Reserved for future use
Sensors description The sensors are listed based on the position on the list. Each one has an ID number, the 2wire channel and the 2wire address to univocally identify it. The sensor ID this parameter is the same reported in the TEMP component for the board. Every sensor will be numbered from 1 to N based on component's structure. Because we have different type of sensor it is possible that the read temperature is adjusted. For example reading the temperature for a sensor inside an ASIC gives the junction temperature so it is adjusted to get the case temperature. if $sadjt_j == 0$ $T_{eff} = Tread + sadv_j$ if $sadjt_j == 1$ $T_{eff} = Tread * (1 + sadv_j /100)$ The offset of this block is fixed at 128 bytes from the base address of the flash block.		
blk_id	2	=0x4253 "BS"
blk_chksum	2	Block checksum
sensor_num	1	Number of sensors for the board - s
sensor_j	4	Sensor ID - sd_j
sensor_2w_chn	1	Sensor 2wire channel
sensor_2w_addr	1	Sensor 2wire address

FIG.4A

400 (CONTINUED)

sensor_adjust_type	1	*s	Sensor reading adjustment type - sadjt $_j$ - 0 = absolute - 1 = percent
sensor_adjust	1		Sensor reading adjustment value - sadj $_j$
sensor_DT_average	1		Delta Temp to be considered average ΔTavth
sensor_DT_max	1		Max Delta Temp to be recorded with comp. ΔTmaxth

Component descriptor

One component is an HW module that can be correlated to a reliability function. Usually components are ASICs having an internal temperature sensor, but it is not limited to that. For this reason the form used to calculate the local temperature for the component is assumed of the form:

$$T_C = C + \Sigma_S cw_S T_S$$

Where T_S is the temperature sampled in the generic sensor. The constant C and the weights cw_S can be determined by pre-FCS measurements and multivariate analysis. The acceleration factor is then:

$$A_C (T) = \exp((1/k)\ \Sigma_{nf}\ Eaf\ (1/(273 + T_{ref}) - 1/(273 + T_C))$$

component_num	1		Number of the tracked components - c
comp_id	4	*c	Component ID (32bit integer)
comp_type	1		Comp Type: PortAsic, Bridge, Fabric, ...
comp_inst	1		Comp sequential number
fr_ref	8		Reference failure rate Λ_C (1/hr, double)
spec_comp_numb	1		Number of this specific component
comp_archit	1		Component architecture csa 0 = serial 1 = redundant
actv_en_num	1		Number of activation energy - nf
actv_en	8*nf		Electronic failure activation energy - Eaf(c,f) - eV (double)
temp_accel_ref	1		Reference temperature for accel. Factors T_{ref}(°C)
temp_w_const_coeff	8		Constant term for temperature definition C (double)
temp_w_exp_coeff	s*8		Weight for expansion temperature determination cw_S (double)

Block 1-30 - Historical data

This part contains historical temperature data. For the format please see par. 4.

Block 31 - Scratch sector

This sector is used as scratch during erase/write of a complete data sector

FIG.4B

500

RAM Memory			
bit-sz	Symbol	Mem-sz	Description
16	δ	1	Reading interval in minutes (15 min)
16	tsave	1	Saving values to NV time (tsave $*\delta$)
32	t1	1	Limit time for infant mortality (t1 $*\delta$)
32	t2	1	Limit time for wear out (t2 $*\delta$)
64	ba	1	Min value for β (at t=0)
64	bb	1	Max value for β (reached at t=2 * t2)
8	nf	1	Number of possible electronic failures
64	Eaf[ ]	nf	Activation energy per failure /8.63 10^{-5} (eV/k)
8	Nj	1	Component number
32	ComplDj	Nj	Identifier
64	Λj		Reference failure rate
64	Trefj		Reference temperature (°K)
8	Cnumj		Number of this specific components
8	Ttype		Temperature measurement (CaseT, indirect)
8	Carch		Architecture (serial, redundant)
64	mj		% of traffic factor
8	Prefj		% of traffic reference factor (50)
64	PosFct		Position factor
64	Λs	1	System failure rate
32	t	1	Total ticks

64	B	1	Value for instantaneous β
			B=1
			If (t<t1) B=ba+((1-ba)/t1)*t
			If (t>t2) B=1+((bb-1)/t2)*(t-t2)

64	Refj[ ]	Nj	Reference reliability index per component $Rrefj[j]=\exp[-(\Lambda j[j]*\delta*t)^{B}]$
64	Rrefs	1	System reference reliability index $Rrefs=\exp[-(\Lambda s*\delta*t)^{B}]$
64	FRrefj[ ]	Nj	Failure rate index per component $FRrefj[j]=(\Lambda j[j])^{B}*B*(\delta*t)^{B-1}$
64	FRrefs	1	System failure rate index $FRrefs=(\Lambda s)^{B}*B*(\delta*t)^{B-1}$
64	Ajft[ ]	Nj*nf	Accelerator factor per component per failure Ajft[j,f]=exp[Eaf[f]*((1/Trefj[j])-(1/(Tj[j]+273))))
64	Ajt[ ]	Nj	Accelerator factor per component $Ajt[j]=\Sigma_{f}(Ajft[j,f])$

FIG.5A

500 (CONTINUED)

bit-sz	Symbol	Mem-sz	Description
64	Ljt[ ]	Nj	Instantaneous failure rate per component Ljt[j]=Ajt[j] * Λj[j]
64	SRjt[ ]	Nj	Instantaneous contribution to the reliability index $SRjt[j]=(Ljt[j])^{B} * B * (\delta * t)^{B-1}$ $SRjt[j]=SRjt[j] * \exp[-(Ljt[j] * \delta * t)^{B}]$
64	Rjt[ ]	Nj	Reliability index per component Rjt[j]=Rjt[j]-SRjt[j]
64	Lst	1	System instantaneous failure rate $Lst=\Sigma_j (Ljt[j])$
64	SRst	1	System inst. contribution to the reliability index $SRst=(Lst)^{B} * B * (\delta * t)^{B-1}$ $SRst=SRst * \exp[-(Lst * \delta * t)^{B}]$
64	Rst	1	System reliability index Rst=Rst-SRst
16	BFsz	1	Ring buffer size
16	BFidx	1	Next avail. Row in ring buffer
32	tofT	BFsz	Reading time
8	Tin		Intake Temperature (°C)
8	Tex		Exhaust Temperature (°C)
8	Tj[Nj]		Case Temperature per component (°C)
64	Lj[Nj]		Inst. failure index per component
64	Ls		System Inst. failure index
64	Rj[Nj]		Reliability index per component
64	Rs		System reliability index

FIG.5B

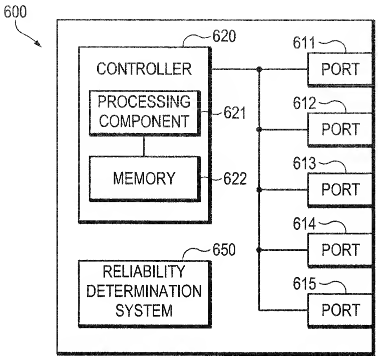

FIG.6

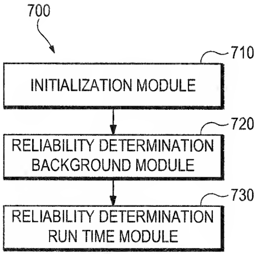

FIG.7

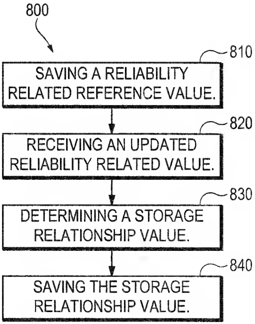

FIG.8

910

911 SENSOR	912 SENSOR	913 SENSOR	914 TIME INTERVAL
27	50	30	0C98719h
28	52	29	0C9871A3h
35	53	25	0C9871B2h

FIG.9A

910

911 SENSOR	912 SENSOR	913 SENSOR	914 TIME INTERVAL
27	50	30	0C987194h
+1	+2	-1	1
+7	+1	-4	1

FIG.9B

910

911 SENSOR	912 SENSOR	913 SENSOR	914 TIME INTERVAL
00011011b	00110010b	00011110b	0C87194h
0001b	0010b	1001b	01h
0111b	0001b	1100b	01h

FIG.9C